

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

LISTING OF CLAIMS:

1. (currently amended): A punch for forging a metallic plate member, comprising:

a first die, adapted to be opposed to a first face of the plate member;

a second die, adapted to be opposed to a second face of the plate member;

a plurality of first projections, provided on the first die and arranged in a first direction with a fixed pitch, each of the first projections being elongated in a second direction perpendicular to the first direction; and

a plurality of second projections, provided on the second die and arranged in the first direction with the fixed pitch, each of the second projections being elongated in the second direction and provided with a concave portion extending in the second direction at a distal end portion thereof,

wherein the plate member is sandwiched between the first die and the second die so that the first projections and the second projections are cut into the plate member in a third direction orthogonal to the first direction and the second direction, to perform a first forging work[[]]; and wherein a portion of each of the first projections that is first brought into contact with the plate member is entirely made flat.
2. (original): The punch as set forth in claim 1, further comprising

a third die, adapted to be opposed to the second face of the plate member on which the first forging work has been performed,

wherein the plate member is sandwiched between the first die and the third die so that only the first projections are cut into the plate member in the third direction, to perform a second forging work.

3. (original): The punch as set forth in claim 1, wherein the second die is arranged such that each of the second projections is opposed to a gap defined between adjacent ones of the first projections.

4. (original): The punch as set forth in claim 1, wherein the second die is arranged such that each of the second projections is opposed to an associated one of the first projections.

5. (original): The punch as set forth in claim 1, wherein the concave portion is arranged at a center portion of each of the second projections with regard to the second direction.

6. (original): The punch as set forth in claim 1, wherein the concave portion has an arcuate shape when viewed from the first direction.

7. (original): The punch as set forth in claim 1, wherein the concave portion is formed with a plurality of flat faces.

8. (original): The punch as set forth in claim 1, wherein a convex portion is formed on a bottom portion of the concave portion.

9. (original): The punch as set forth in claim 8, wherein the convex portion has a height such an extent that a plurality of concave portions are substantially defined by the convex portion.

10. (original): The punch as set forth in claim 1, wherein a recess portion is formed at a bottom portion of the concave portion.

11. (original): The punch as set forth in claim 1, wherein a length of the concave portion in the second direction is $\frac{2}{3}$ or less of a length of each of the second projections in the second direction.

12. (original): The punch as set forth in claim 1, wherein a ratio of a depth of the concave portion with respect to a length of the concave portion in the second direction falls within a range of 0.05 to 0.3.

13. (original): The punch as set forth in claim 1, wherein a ratio of a depth of the concave portion with respect to a height of each of the second projections falls within a range of 0.5 to 1.

14. (original): The punch as set forth in claim 1, wherein at least the concave portion of each of the second projections is finished with either mirror finishing or chromium plating.

15. (original): The punch as set forth in claim 1, wherein each of the second projections has a wedge-shaped cross section when viewed from the second direction.

16. (original): The punch as set forth in claim 15, wherein a distal end angle of the wedge-shaped cross section is 90 degrees or less.

17. (original): The punch as set forth in claim 1, wherein the fixed pitch is 0.3 mm or less.

18. (original): The punch as set forth in claim 2, wherein:
the third die is formed with a pair of third projections arranged in the second direction and elongated in the first direction so as to define a groove therebetween; and
each of the third projections has a flat distal end face.

19. (original): The punch as set forth in claim 18, wherein the concave portion in the second die and the groove in the third die are placed at a same position with respect to the plate member in connection with the second direction.

20. (original): The punch as set forth in claim 18, wherein sloped flat faces continued from the flat distal and face are provided at both end portions in the first direction of each of the third projections, such that a portion closer to an end in the first direction of each of the third projections is more separated from the first die.

21. (original): The punch as set forth in claim 18, wherein a depth of the groove falls within a range of 0.05 mm to 0.15 mm, and a length in the second direction of the groove falls within a range of 0.5 mm to 1 mm.

22. (original): The forging punch as set forth in claim 2, wherein the second die and the third die are arranged such that the first forging work and the second forging work are performed in a progressive manner.

23. (currently amended): A forging apparatus comprising ~~the punch as set forth in claim 1~~;

a first die, adapted to be opposed to a first face of the plate member;

a second die, adapted to be opposed to a second face of the plate member;

a plurality of first projections, provided on the first die and arranged in a first direction with a fixed pitch, each of the first projections being elongated in a second direction perpendicular to the first direction;

a plurality of second projections, provided on the second die and arranged in the first direction with the fixed pitch, each of the second projections being elongated in the second

direction and provided with a concave portion extending in the second direction at a distal end portion thereof; and

an actuator, operable to actuate at least one of the first die and the second to sandwich the plate member therebetween so that the first projections and the second projections are cut into the plate member in a third direction orthogonal to the first direction and the second direction, wherein a portion of each of the first projections that is first brought into contact with the plate member is entirely made flat.

24. (withdrawn): A method of forging a metallic plate member, comprising steps of:
providing a first die, in which a plurality of first projections are arranged in a first direction with a fixed pitch, each of the first projections being elongated in a second direction perpendicular to the first direction;

providing a second die, in which a plurality of second projections are arranged in the first direction with the fixed pitch, each of the second projections being elongated in the second direction and provided with a concave portion extending in the second direction at a distal end portion thereof;

providing a third die, in which a pair of third projections arranged in the second direction and elongated in the first direction so as to define a groove therebetween, each of the third projections having a flat distal end face;

opposing the first die to a first face of the plate member while opposing the second die to a second face of the plate member;

performing a first forging work by sandwiching the plate member with the first die and the second die in a third direction orthogonal to the first direction and the second direction, so as

to generate a plastic flow of a material in the plate member into gaps defined between the first projections while generating a plastic flow of the material into the concave portion of each of the second projection;

opposing the third die to the second face of the plate member, after the first forging work;
and

performing a second forging work, by sandwiching the plate member with the first die and the third die in the third direction, such that the flat distal end face of each of the third projections generates a plastic flow of the material into the gaps between the first projections, while a protrusion formed on the plate member by the concave portion is received by the groove,

wherein a plurality of recesses formed by the first projections are partitioned by partition walls formed by the material flown into the gaps between the first projections.

25. (withdrawn): A method of manufacturing a liquid ejection head, using the forging method as set forth in claim 24, the manufacturing method comprising steps of:

forming a through hole in each of the recesses so as to communicate each of the recesses with the second face of the plate member;

joining a sealing plate onto the first face of the plate member so as to seal the recesses;

providing a metallic nozzle plate formed with a plurality of nozzles; and

joining the nozzle plate, with an adhesive agent, onto the second face of the plate member such that each of the nozzles is communicated with an associated one of the recesses via the through hole,

wherein the liquid ejection head is configured such that liquid droplets are ejected from the nozzles by pressure fluctuation generated in liquid contained in the recesses.

26. (withdrawn): The manufacturing method as set forth in claim 25, wherein a plurality of dents formed by the second projections and remained on the second face of the plate member are used to receive excess adhesive agent when the nozzle plate is joined onto the second face of the plate member.

27. (withdrawn): The manufacturing method as set forth in claim 25, wherein a height of one of the flat distal end faces of the third projections which is closer to a portion where the through hole is to be formed is lower than the other one of the flat distal end faces.

28. (withdrawn): A liquid ejection head manufactured by the method as set forth in claim 25, wherein a plurality of dents are arranged on the second face of the plate member with the fixed pitch.

29. (withdrawn): The liquid ejection head as set forth in claim 28, wherein each of the dents is formed in the vicinity of the through hole.

30. (withdrawn): The liquid ejection head as set forth in claim 28, wherein the plate member is comprised of nickel.